National Aeronautics and Space Administration

NASAfacts

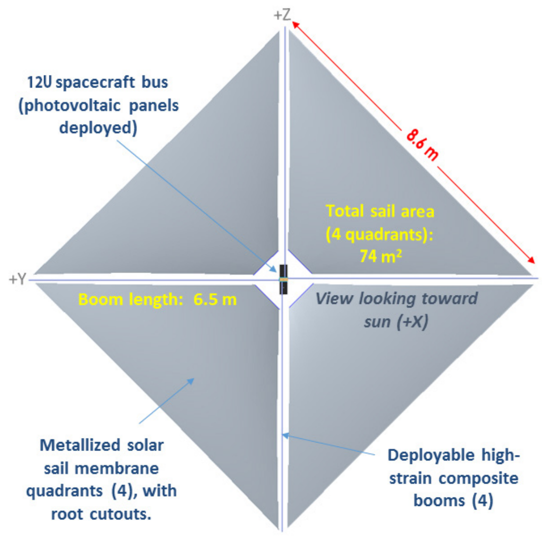
Advanced Composite Solar Sail System

Demonstrating Deployable Composite Solar Sails for Future Deep Space Small Spacecraft

NASA is developing new deployable structures and materials technologies for solar sail propulsion systems destined for future low-cost deep space missions. Solar sails eliminate the need for conventional rocket propellants, relying instead upon the pressure of sunlight to generate continuous thrust. They can operate indefinitely, limited only by the space environment durability of the solar sail materials and spacecraft electronic systems.

At NASA's Langley Research Center in Hampton, Virginia, and NASA's Ames Research Center in California's Silicon Valley, researchers and engineers are planning a mission to demonstrate the next generation of solar sail technology for small interplanetary spacecraft. As part of this development effort, the Advanced Composite Solar Sail System (ACS3) will demonstrate deployment of an approximately 800 square foot (74 square meter) composite boom (mast) solar sail system in low-Earth orbit. This will be the first use of composite booms as well as sail packing and deployment systems for a solar sail in orbit. Also developed for ACS3 is an innovative tape-spool boom extraction system to minimize blossoming, or jamming, of the coiled booms during deployment. The ACS3 mission will serve as a technology pathfinder for a future, 5382 square foot (500 square meter) composites-based small spacecraft solar sail system suitable for low-cost heliophysics research and small body planetary science. The solar sail system may also serve as a communications relay supporting human spaceflight missions.

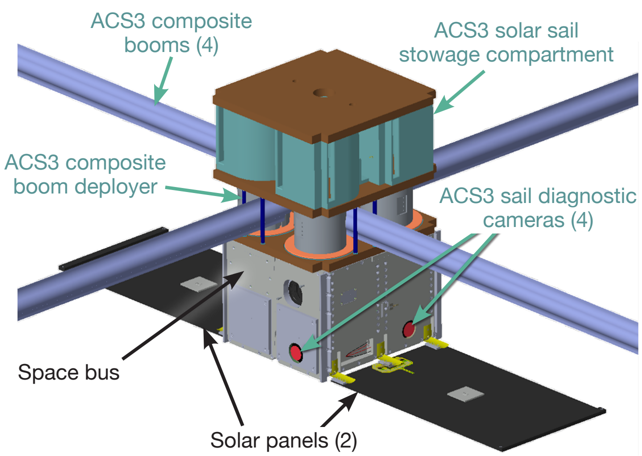
Since solar radiation pressure is extremely small, practical solar sails must be very large, lightweight and extremely compact to stow within CubeSat and small satellite payload volumes. The ACS3 solar sail system is sized to fit within a 12-unit (12U) CubeSat. The solar sail consists of four, 215 square foot (20 square meter), triangular aluminum-coated plastic membrane sails supported by four approximately 21-foot long (6.5 meter) thin-ply collapsible composite booms. The thin-ply composite booms are flattened and rolled onto spools for compact stowage within the spacecraft. Strong and lightweight, the booms are 75% lighter and experience 100 times less in-space thermal distortion than the current state-of-the-art metal booms. Thermal distortion is a particularly difficult problem with metallic deployable booms, and can produce unwanted bends in the shape of antennas and reflectors, solar arrays, and solar sails.



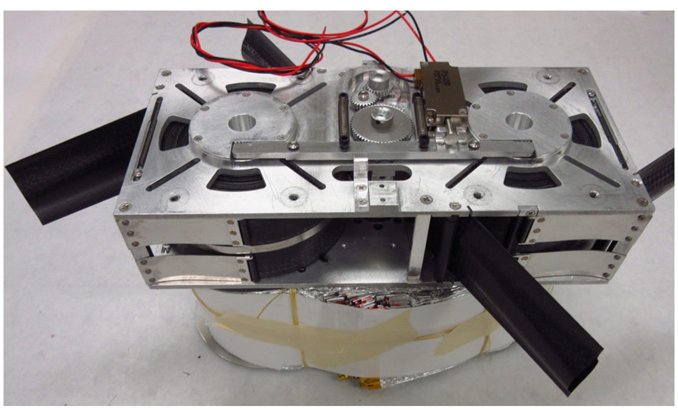
The ACS3 experimental solar sail when fully deployed is approximately 8.6 m by 8.6 m in size (74 m^2). Deployment of the solar sail takes between 20 and 30 minutes.

The ACS3 solar sail will be deployed and tested in low-Earth orbit. During the flight demonstration, the solar sail will be kept aligned with the orbital plane of Earth in order to minimize aerodynamic drag effects (also called resistance) and maximize time on orbit. A suite of onboard digital cameras will obtain images of the sail during and after deployment, which will be transmitted to the ground for use by the solar sail structures and materials team to assess the shape and precision of the deployed solar sail and composite booms. At the conclusion of the 5-month ACS3 mission, the solar sail will be turned into the direction of flight to maximize aerodynamic drag and de-orbit the vehicle as quickly as possible. The collected ACS3 flight data will be used to design future, larger-scale composite solar sail systems based on ACS3 technology.

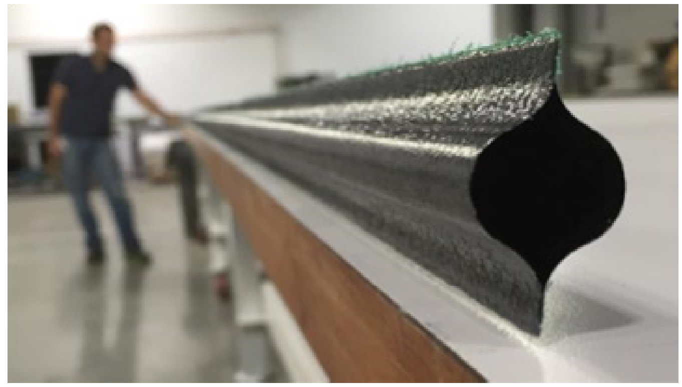
The ACS3 project is a collaboration between Langley and Ames. The ACS3 project is managed and funded by the Small Spacecraft Technology (SST) program within the Space Technology Mission Directorate (STMD). ACS3's composite boom technology is being developed under STMD's Game Changing Development (GCD) program. SST expands U.S. capability to execute unique missions through rapid development and in-space demonstration of capabilities for small spacecraft applicable to exploration, scienc, and the commercial space sector. SST will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.



The ACS3 solar sail system fits within a 12U CubeSat at launch. Cameras will record images of the solar sail deployment and final shape for analysis on the ground.



The ACS3 solar sail engineering development unit (EDU) is the size of a small shoebox, approximately 8 in. x 4 in. x 6 in. (20 cm x 10 cm x 15 cm).



The ACS3 solar sail booms are stiff, light weight, and compactly stow. Their composite construction also make them less prone to bending when heated by the sun.

For more information about the SST, visit:
www.nasa.gov/directorates/spacetech/small_spacecraft/

For more information about the GCD, visit:
www.nasa.gov/directorates/spacetech/game_changing_development/

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